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CONCORD GRAPE JUICE: MANUFACTURE AND CHEMICAL COMPOSITION.

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SCOPE OF THE INVESTIGATION.

Although a large amount of work has been done on the chemical composition of American grapes, and several bulletins on the subject have been issued in the last few years by the Department of Agriculture, the information presented is restricted principally to the acid and sugar content of American grapes, and, in the main, is of interest to viticulturists only. The literature appears to contain no specific information concerning the manufacture and chemical composition of commercial Concord grape juice. The purpose of the investigation, the results of which are embodied in this bulletin, was to obtain information on the manufacture of Concord grape juice and to procure chemical data on authentic samples of this product.

The first step of the work consisted in taking, under the supervision of a member of the Bureau of Chemistry, 5-gallon samples of regular factory juices. Some of these samples were analyzed immediately, and the others were sealed, placed in the storage vaults of the respective factories, and allowed to remain there with the regular factory juices until the bottling season, when they were bottled in the presence of a chemist, under the prevailing factory conditions, and shipped to Washington for chemical analysis. A comparison of these two sets of analyses shows the changes in chemical composition which take place during the storage period.

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[1] It is desired to express appreciation, for their cooperation, to Mr. B. B. Wilcox, who was in charge of the work conducted at the factory in the Hudson River district, and to Mr. M. J. Ingle, who assisted in the chemical analysis of the juices.

The work was extended over a period of three years, during which time several hundred samples were taken and analyzed. The principal factories in the State of New York were chosen for study because the great bulk of Concord grape juice is manufactured in this State. One representative of the Bureau of Chemistry was sent to Ulster County in the Hudson River district, in the eastern part of the State, and one to Chautauqua County, in the Chautauqua district, in the western part of the State. Of the five New York factories visited, four are located in the Chautauqua and one in the Hudson River district. Later the Lake Erie district, in the State of Ohio, was included. The report covering the investigation in this district is given separately, because of the decided difference in the process of manufacture. Laboratories were equipped and maintained during the pressing seasons, one factory in each of the districts being selected for the purpose.

CHARACTER OF FRUIT USED.

The Concord grape is a variety of *Vitis labrusca* L. It is one of the few black grapes which come well recommended as a standard grape. It is a midseason variety, and this fact in itself is reason enough for its extensive cultivation, since it is less liable to frost damage than the later varieties.

A grape which deserves mention as a rival for grape-juice manufacturing purposes is the Clinton. The Clinton, which belongs to the *Vitis riparia-x-labrusca*, lacks the foxy flavor of the Concord. It is very productive and carries more sugar than the Concord. The Clinton is exceedingly hardy, even more so than the Concord, and thrives on soils and under conditions not so favorable to the Concord. The color of the juice is a rich red, and the berry, although somewhat smaller in size than that of the Concord, is juicy and vinous. This variety is not extensively grown at present.

The Concord grape is very juicy, of medium acidity, and the juice has a rich red color. It is very hardy and productive, and, mainly for these reasons and because of its color, it has become the favorite for the manufacture of red grape juice.

On the whole, the grapes used during the investigation in the various factories were of good quality. The grapes of the seasons of 1913 and 1914 were slightly better than those of 1912 in sugar content and general maturity. It is natural that there should be more or less variation in sugar content, even in fruit from the same locality, since it is obvious that the nature of the soil, the location and drainage of the vineyard, and the manner of cultivation have a very decided effect upon sugar formation. Table 1 shows this variation in solids and alcohol content of six samples of grapes produced in different sections of the Chautauqua belt.

TABLE 1.—*Variation in solids and alcohol content of Concord grapes from different sections of the Chautauqua belt.*

Section.	Condition of grapes.	Solids per 100 cc.	Sugars as invert before inversion per 100 cc.	Non-sugar solids per 100 cc.	Alcohol per 100 cc.
		Grams.	*Grams.*	*Grams.*	*Grams.*
Silver Creek	Well ripened	19.08	17.02	2.06	0.06
Fredonia	Fairly well ripened	20.81	18.72	2.09	.06
Portland	Well ripened	19.89	17.87	2.02	.06
Forsyth	do	19.31	17.30	2.01	.06
Irving	do	16.44	14.15	2.29	.06
Ripley	Overripe	18.50	15.98	2.52	.12

The samples represented the average from several crates taken from deliveries to the factory. All samples were in good condition and similar in appearance. The juices were cold hand pressed. Table 1 shows a variation of about 4.5 grams of sugar per 100 cubic centimeters. The sample from the Irving section, although of good appearance, had a flat, insipid taste, and was low in acid. The sample from Ripley showed signs of shriveling, and contained a small amount of damaged berries.

While the greater part of the fruit was received in wagonlots directly from the farmers, some was received in refrigerator cars. Generally speaking, shipments made in cars were very satisfactory, no particular damage to the grapes resulting when loaded carefully. In one case a shipment was in transit a week, and showed no signs of deterioration of any kind, the grapes being in good condition when unloaded at the factory. Occasionally, however, upon opening a car a distinct odor of fermentation was perceptible. In such cases crushed and moldy fruit, due to overfilling of the crates, was found to be present in appreciable amounts. Alcohol determinations on samples taken from these cars showed surprisingly low amounts of this ingredient.

A great number of alcohol determinations were made on grapes of varying quality. It was found that good, sound fruit contains only small amounts of alcohol, varying from 0.02 to 0.07 gram per 100 cubic centimeters of juice. That sound fruit should be low in alcohol is self-evident, since yeasts can not penetrate the sound normal skin of the grape. Only in cases where the juice has been exposed through injury to the berry, as in the case of crushed or detached berries, is it possible for alcohol to form. Under such conditions the alcohol content may be as high as 0.3 gram per 100 cubic centimeters of juice. To prove this point the alcohol content of two samples of the poorest grapes obtainable was determined. The berries were badly crushed and covered with mold. These juices showed 0.22 and 0.27 gram of alcohol per 100 cubic centimeters.

To ascertain the effect of standing on the development of alcohol in grapes, a box of fruit was allowed to stand at room temperature, and the fruit analyzed for alcohol from time to time. The fruit was of good quality, only slightly damaged.

TABLE 2.—*Alcohol content of Concord grapes.*

	Grams per 100 cc.
Fresh grapes	0.02
After standing:	
48 hours	.08
72 hours	.09
96 hours	.10

After standing 96 hours the grapes had a dead, dull appearance, and had begun to shrivel.

These experiments are of more than average interest because they show that with careful handling grapes do not develop alcohol to any extent, and that only in cases of great damage is the alcohol content as high as 0.30 gram per 100 cubic centimeters. This fact is of importance to the juice manufacturer because grapes must often stand several days before they can be pressed.

It is evident, therefore, that damage from alcoholic fermentation is highly improbable with grapes of good quality, and that even the poorest fruit seldom contains more than appreciable amounts of alcohol. Far more serious is the presence of mold in grapes, because the juice made from fruit so infested may acquire an unpleasant, musty odor. In order to avoid such a condition, the producer is warned against filling the crates too full, and, wherever it is necessary to hold the grapes any length of time, to store them in such a manner that air can circulate freely throughout the stacks.

MANUFACTURE OF COMMERCIAL CONCORD GRAPE JUICE.

The grapes should be well matured and of the best quality obtainable. Immature fruit or green grapes yield juices of inferior quality because of high acidity, lack of sufficient sugar and color, and the presence of large amounts of green coloring matter. The well-matured grapes are gathered in wooden crates of about 25 pounds capacity, and are either crushed immediately or air-ripened. Some difference of opinion as to the merits of these procedures exists. Careful air-ripening, however, mellows the fruit, develops flavor, and admits of a better condition for the process of juice manufacture than can be attained by using freshly picked fruit. For air-ripening it is of the utmost importance that the boxes of fruit be stacked in a cool place in such a manner that air may circulate freely throughout the stack. This precaution should not be overlooked; otherwise a rise in temperature may cause molding of the fruit. Overfilling the crate should be carefully guarded against to avoid crushing, with resultant souring of the fruit and possible fermentation. With proper care grapes may be kept for several days without particular harm to the fruit.

A desirable arrangement for a grape-juice factory is one which allows the product to fall from one operation to the next by gravitation. In this way unnecessary pumping is avoided, the metallic surface offered to the pulp or juice is reduced to a minimum, and the work of keeping the juice lines sweet and clean facilitated.

As to the effect of metals on the quality of the juice, experience has shown that aluminum offers more resistance to the acid of the juice and affects the color less than other base metals. Other metals, such as copper and tin, have been tried. Tin gives the juice a bitter metallic taste and a bluish tinge, and consequently affects the quality materially. Iron also affects the quality of the juice, giving it a purple tinge. It was found that when bottled the product of one of the factories included in this investigation showed a purple ring immediately on the surface. The cause of this ring was traced to the use of iron coils and pipes, which resulted in the formation of iron tannate.

The gravity plan entails the conveying of the fruit to the highest point in the system; that is, to the first unit in the chain of operations, the crusher. In some factories the fruit is washed in order to remove foreign matter such as dust and leaves before it is crushed. For this purpose the grapes are dumped into a tank of running water, in the bottom of which an endless belt is operated to remove the grapes from the water, and after proper draining convey them to the crusher.

The process of juice manufacture may be divided into six distinct manipulations:

1. Crushing and stemming the fruit.
2. Heating the crushed fruit.
3. Pressing the heated fruit.
4. Sterilizing and bottling the juice for storage.
5. Siphoning the juice.
6. Bottling and pasteurizing the trade juice.

CRUSHING AND STEMMING THE FRUIT.

The crusher consists of two rollers of metal, usually bronze, revolving at high speed. The rolls are set in such a manner as to avoid the crushing of the stems and seeds. The stemmer is a cylindrical revolving drum, inside of which are arranged revolving fingers that separate the berries from the stems. The crushed berries and liberated juice pass through openings in the side of the drum and fall through to the cooker, while the stems are pushed out of the drum by the fingers.

HEATING THE CRUSHED FRUIT.

From the stemmer the crushed fruit and the liberated juice fall into the heating kettles, commonly called cookers.

The grape berry may be divided into two main parts, the skin and the pulp. The pulp of the grape is practically colorless and carries most of the juice. The skin furnishes the coloring matter so much desired by the manufacturer of Concord grape juice, as well as less desirable ingredients. The juice of the pulp is sweet and pleasant but lacks body and character. The juice from the skin is highly colored, high in acid and tannin, and in mineral ingredients and body, but low in sugar. By judiciously mixing these two juices a better product, of more pleasing appearance, is obtained than would result from either of these juices alone.

Such a modified juice is obtained by the simple operation of heating the crushed fruit to suitable temperatures. The very closest attention is required, however, to secure the best results. Temperatures which are too high give the juice a harsh taste, lacking in quality but high in coloring matter, and if carried to excess may ruin the flavor and aroma completely. On the other hand, low temperatures do not draw sufficient color, and such juices are wanting in body, though pleasant in taste and aroma.

In choosing the best temperature for heating the crushed fruit, the quality of fruit must be taken into consideration. Ripe fruit or fruit that has been air-ripened yields its desirable ingredients at a lower temperature than immature fruit. Also the pressing process must be considered in connection with the heating, as by applying more or less pressure the color, tannin content, and body of the juice may be regulated, the greater pressure giving the more color, tannin, and body to the juice, as well as delivering the greater amount of juice. It is apparent that to regulate the tannin content and the body of a juice by using a smaller amount of pressure, means a loss of juice. Consequently it is better to regulate the heating process and not rely altogether upon the pressing process to correct the quality of the juice. In this connection it should be said that although low temperatures during heating are very desirable for attaining quality, higher temperatures give a better dissolution of the fruit and a better yield of juice. As is evident from what has just been said, it is not possible to fix a definite temperature for the heating process. The temperature, however, should be between 135° and 150° F. The time required for heating is simply the time necessary to heat to the desired temperature.

By the heating of the crushed fruit the skins are drawn upon for color and body. A cold-pressed juice lacks the body and color of the hot-pressed juice, so this may be said to be the character-forming step. The effect of heating upon the chemical composition of the pressed juice may be seen by a comparison of the data given in Table 3, which shows the chemical composition of juices pressed from the heated and unheated fruit.

To obtain the cold-pressed juice a well-mixed sample of the pulp from the stemmer was pressed by hand through several thicknesses of cheesecloth and filtered through cotton. This gave the sample mentioned in Table 3 under the heading "Before heating." The same batch of pulp was again sampled after it had been heated to 150° F. in the cooker and the juice expressed in the same manner. This gave the sample in Table 3 under the heading "After heating."

Table 4 summarizes the results given in Table 3, and shows the increases in the various ingredients caused by heating the pulp.

TABLE 3.—*Chemical composition of hot and cold pressed Concord grape juices.*

Experiment.	Juice pressed before or after heating.	Solids, per 100 cc.	Sugar as invert before inversion, per 100 cc.	Nonsugar solids, per 100 cc.	Total acid as tartaric, per 100 cc.	Total tartaric acid, free and combined, per 100 cc.	Ash, per 100 cc.	Alkalinity of soluble ash, N/10 acid, per 100 cc.	Alkalinity of insoluble ash, N/10 acid, per 100 cc.	Free tartaric acid, per 100 cc.	Cream of tartar, per 100 cc.	Tannin and coloring matter, per 100 cc.
		Gms.	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Cc.*	*Cc.*	*Gms.*	*Gms.*	*Gms.*
1	Before........	17.20	14.36	2.84	0.78	0.63	0.26	30.0	3.0	0.14	0.56	0.08
	After..........	17.83	14.58	3.25	1.12	1.04	.46	55.8	4.8	.13	1.05	.24
2	Before........	16.33	13.88	2.45	.74	.63	.27	33.2	2.8	.09	.62	.07
	After..........	17.25	13.62	3.63	1.01	.97	.43	52.4	4.0	.12	.99	.19
3	Before........	16.10	13.74	2.36	.84	.61	.20	22.4	3.6	.22	.42	.06
	After..........	17.17	13.74	3.43	1.16	1.01	.33	49.2	4.4	.21	.93	.20
4	Before........	16.57	14.32	2.25	.75	.55	.22	25.2	2.8	.13	.47	....
	After..........	18.50	15.12	3.38	1.10	.98	.39	44.0	4.0	.26	.83	....
5	Before........	15.66	13.38	2.28	.80	.65	.22	24.4	2.6	.24	.46	....
	After..........	16.44	13.29	3.15	1.07	.96	.33	38.0	3.8	.33	.71	....
6	Before........	16.28	13.91	2.37	.79	.57	.23	26.0	3.6	.13	.49	....
	After..........	17.41	13.83	3.58	1.09	.94	.37	41.2	4.4	.26	.77	....

TABLE 4.—*Maxima, minima, and averages of data given in Table 3: Chemical composition of hot and cold pressed Concord grape juices.*

Juice pressed before or after heating.	Solids, per 100 cc.	Sugar as invert before inversion, per 100 cc.	Nonsugar solids, per 100 cc.	Total acid as tartaric, per 100 cc.	Total tartaric acid, free and combined, per 100 cc.	Ash, per 100 cc.	Alkalinity of soluble ash, N/10 acid, per 100 cc.	Alkalinity of insoluble ash, N/10 acid, per 100 cc.	Free tartaric acid, per 100 cc.	Cream of tartar, per 100 cc.	Tannin and coloring matter, per 100 cc.
Maximum:	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Cc.*	*Cc.*	*Gms.*	*Gms.*	*Gms.*
Before	17.20	14.36	2.84	0.84	0.65	0.27	33.2	3.6	0.24	0.62	0.08
After	18.50	15.12	3.63	1.16	1.04	.46	55.8	4.8	.33	1.05	.24
Minimum:											
Before	15.66	13.38	2.25	.74	.55	.20	22.4	2.6	.09	.42	.06
After	16.44	13.29	3.15	1.01	.94	.33	38.0	3.8	.12	.71	.19
Average:											
Before	16.36	13.93	2.43	.78	.61	.23	26.9	3.1	.16	.50	.07
After	17.43	14.03	3.40	1.09	.99	.39	46.7	4.2	.22	.88	.21
Average increase.	1.07	.10	.97	.31	.38	.16	19.8	1.1	.06	.38	.14

Table 4 shows very plainly that during the heating process the juice acquires more body, acid constituents, and color. The increase in acidity, which is very marked, is due chiefly to the presence of cream of tartar and small amounts of other organic acids, principally malic and tannic. The increase in nonsugar solids is due to pectin substances and gums, coloring matter, and the organic acids just mentioned and their salts. These various increases are due to the behavior of the skin of the grape berry during the heating process.

During the storing period the quantity of cream of tartar derived through the heating process is largely eliminated through precipitation (Tables 7 and 8), so that the stored juice contains approximately the same amount of this ingredient as is contained in the cold-pressed juice. During the storage of the juice, part of the pectin substances and gums and part of the tannin and coloring matter are removed from the juice. With the decrease in cream of tartar during storage there is a corresponding decrease in total solids, nonsugar solids, total acidity, total tartaric acid, ash, and the alkalinity of the water-soluble ash.

The heating kettles are of aluminum and are steam-jacketed. Steam-jacketed, glass-lined steel tanks, or wooden vats fitted with aluminum steam coils, may, however, be employed with success. The heating kettles, or vats, are equipped with agitators to allow uniform heating of the pulp. That thorough agitation while heating the crushed fruit is of the utmost importance is self-evident, since to allow the mass to rest would overheat the portion next to the heating surface and cause scorching. Scorching also results from filling the kettles while hot. These two precautions should be closely observed in order to avoid a cooked taste in the juice.

From the heating kettles the fruit is dropped to the press room, where it is made up into cheeses and pressed.

PRESSING THE HEATED FRUIT.

The hot pulp is enveloped in strong, coarse-meshed cloths to form layers which are stacked on top of one another. These stacks or "cheeses," as they are called, are then subjected to pressure. The height of the stacks varies in different factories. It may be said, however, that low cheeses are to be preferred to high ones, because they allow a better yield of juice on account of the greater elasticity of the higher cheeses.

The presses used in the factories are of two types, the hydraulic or power press and the screw or wine press. The number of layers varies with the size and power of the press, and the size of the layers themselves. As a rule, 10 layers (48 by 48 inches) constitute a cheese. While the cheese is being prepared and the number of layers increases, the pressure on the cheese grows, thereby increasing the flow of juice. This flow of juice is called the free-run juice, since it is the juice which is recovered by the weight of the cheese itself without additional pressure. This juice is lighter in color than the juice obtained after pressure is administered, and is practically the juice from the pulp proper. It is materially lower in acid and has less tannin and body than the final juice after the pressing process is completed. The free run amounts to about 56 per cent of the entire quantity of available juice in the fruit. Before the pressure is applied the cheese should be allowed to settle. This settling period is of importance, as it allows the coarse particles of pulp gradually to shift with the flow of juice to the sides of the cloths, followed up by finer material; thus a very efficient filter for the juice is provided. If the pressure were applied without allowing the cheese to settle, the advantage due to the collection of this filtering material and its consequent clarifying effect would be sacrificed. Although obviously advantageous to allow the cheese to settle before applying pressure, it is not absolutely necessary. It is evident, however, that the greater the amount of suspended matter removed from the juice before it is bottled for storage the better will be the precipitation so far as compactness is concerned, an advantage not to be underestimated because of the better conditions for siphoning. Although the time allowed for the settling of the cheese varies in the different factories, 15 minutes is quite sufficient for this operation. This is shown in figure 1. The first 10 minutes served to build the cheeses. The time of settling was varied to show the effect of time upon the recovery of free-run juice. Table 5 gives the data shown in figure 1.

TABLE 5.—*Amount of juice recovered as free run and under pressure.*

Kind of juice.	Experiment 1.	Experiment 2.
1. Juice delivered during cheese making..........per cent..	33	36
2. Total free-run juice..........do....	57	55
3. Juice delivered at low pressure..........do....	33	28
4. Juice delivered at high pressure..........do....	10	17
5. Juice recovered per ton of pulp..........gallons..	183	193
Total amount of free run, 80 per cent is recovered during cheese making and in the first 15 minutes after the cheese is prepared.		

It is evident that the greater part of the total available juice of the fruit exists in the free state, and that it requires but little pressure to recover from 83 to 90 per cent of the entire yield.

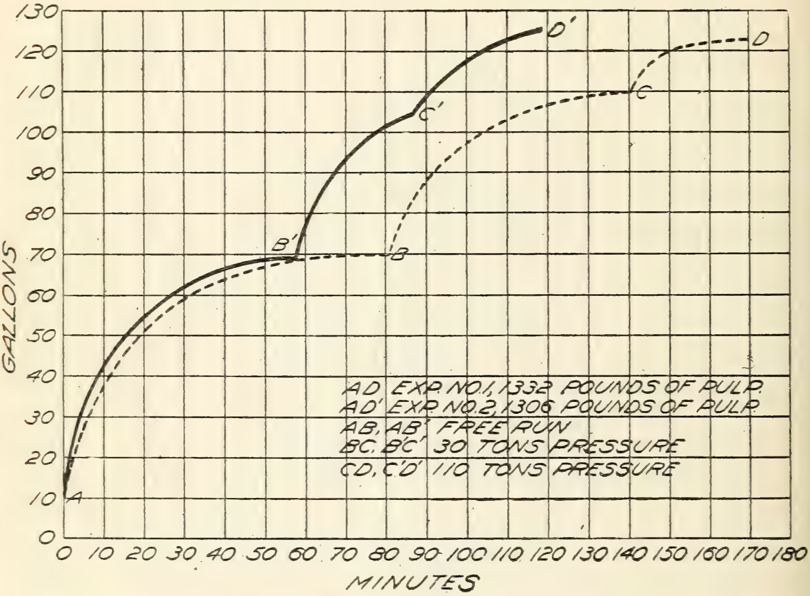

FIG. 1.—Relation between time allowed for settling and amount of free-run juice recovered.

Figure 1 shows that after 25 minutes—a 10-minute cheese-making and 15-minute settling period—in Experiment 1, 56 gallons of juice out of 70 gallons, the total amount of the free run, is recovered, or 80 per cent; and in Experiment 2, 58 gallons out of 69, or 84 per cent, is recovered. This proves that a 15-minute settling period is sufficient to recover more than 80 per cent of the juice obtainable by settling or free run.

After the cheese has settled, pressure is gradually applied and increased until it reaches about 100 tons, figured on a 10-inch ram, or about 2,546 pounds per square inch on the ram. The manner of increasing or holding the pressure varies in different factories. In the majority, however, the time allowed for the pressing is about one hour, including the 35 minutes for reaching high pressure of 100 tons, and 25 minutes at high pressure, so that the entire pressing from the time the first layer is made through the settling period to the time the pressure is released occupies about one hour and 25 minutes.

Table 6 shows the differences in composition of the juices obtained at various pressures.

TABLE 6.—*Chemical composition of Concord grape juices obtained at various pressures.*

Pressure.	Experiment.	Time.	Solids, per 100 cc.	Sugars as invert before inversion, per 100 cc.	Non-sugar solids, per 100 cc.	Ash, per 100 cc.	Total acid as tartaric, per 100 cc.	Total tartaric acid, free and combined, per 100 cc.	Tannin and coloring matter, per 100 cc.
		Min.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Free run	1	15	16.62	13.48	3.14	0.410	1.11	0.99	0.27
	2		16.78	13.36	3.42	....	1.04	.99	.26
0 to 25 tons	1	15	17.30	13.82	3.48	....	1.20	1.01	.28
	2		16.91	13.34	3.57	....	1.17	1.06	.28
25 to 75 tons	1	15	17.48	13.86	3.62	....	1.25	1.04	.31
	2		....	....	....	....	....	....	....
75 to 100 tons	1	5	17.41	13.88	3.53	....	1.25	1.07	.33
	2		16.78	13.07	3.71	....	1.28	1.15	.29
Drainings at 100 tons	1	25	17.48	13.66	3.82	.484	1.27	1.12	.36
	2		16.73	12.93	3.80	....	1.31	1.17	.32

The data in Table 6 were obtained on hydraulic presses with 10-inch rams. The pulp was heated to about 150° F. and made into cheeses consisting of 10 layers, each 48 by 48 by 3 inches. The completed cheese was allowed to settle for about 15 minutes under the weight of the piston head. The juice expressed in this manner, which is termed "free run," amounted to about 65 per cent of the total available juice. Pressure was then applied, and gradually brought up to 100 tons; from 0 to 25 tons in about 15 minutes; from 25 to 75 tons in about 15 minutes; from 75 to 100 tons in about 5 minutes. At 100 tons the pressure was held about 25 minutes, so that the total time of pressing after the cheese was prepared was about 1 hour and 15 minutes.

The data are self-explanatory. They show that as the pressure increases the juice becomes more fullbodied and richer in color and acid ingredients.

After the cheese has been allowed to drain at high pressure the pressure is released. The residue in the cloths, called the pomace, amounts to about 15 per cent of the heated fruit. A pomace which has been subjected to 100 tons pressure is dry and tough. It contains, on an average, about 60 per cent moisture and 40 per cent of solids. The dried pomace contains about 20 per cent sugar and about 4 per cent of acid as tartaric. The pomace remaining in the cloths is removed by shaking the cloths. In order to insure the life of the cloths, it is advisable to wash them each time they are used. In some factories where screw presses are employed the cloths are not washed oftener than every fourth time of using. After the cloths have been washed they are centrifuged or passed through a wringer to remove the excess of moisture, and are ready for use again. In one factory the washed cloths are dried by blowing hot air through them.

STERILIZING THE JUICE AND BOTTLING IT FOR STORAGE.

After having been strained through several thicknesses of burlap to remove coarse particles, the juice flowing from the presses is united in the sterilizers. The sterilizers are aluminum vats, or kettles, and are steam-jacketed. In these the juice is heated to destroy the living organisms, so that it may keep during the precipitation period. If the juice, just as it runs from the presses, were filled into the precipitation vessels, it would ferment in a very short time.

The temperature to which the juice is subjected in the sterilizing process is of the utmost importance to the flavor and aroma. The effect of operations carefully conducted during the earlier stages of the manufacturing process may be completely destroyed by carelessness during sterilization. This pertains not only to the temperature employed during sterilization, but also to the manner in which the kettles are filled. As in the process of heating the pulp, care must be taken not to run the juice into a hot kettle, because this would scorch the juice and give it a cooked taste. All kettles should be filled at a low temperature and then heated. This rule applies to every process in which the juice is heated. The sterilizing temperature varies in the different factories, ranging from 176° to 190° F. It is, of course, evident that the lowest possible temperature affording thorough sterilization is the best. It is inadvisable, however, to go much lower than 180° F. on account of the danger of fermentation.

The precipitating vessels, glass carboys, or jugs of 5-gallon capacity are now filled to within a few inches from the top with the hot sterile juice. These have previously been heated in steam boxes for the purpose of sterilizing them and of allowing them to accommodate themselves gradually to the temperature of the juice they are to receive, this latter precaution being necessary to avoid breakage. As soon as the juice has been poured in, the vessels are closed with corks of good quality, prepared by dipping into heated paraffin to close up any pores or canals. The paraffining of the corks is a very important measure, as the contraction of the cooling juice would draw air through any space which might be left, causing mold or even fermentation. The cleaning of glass carboys can be more easily supervised, and the siphon can be placed to better advantage in them than in jugs; the majority of factories therefore prefer the carboys. In selecting the carboys or jugs care should be taken that the mouth of the container has no defect and is as round as possible, so that the cork may fit tightly. Furthermore, in selecting glass carboys, vessels with perpendicular sides should be chosen in preference to those with sloping sides, because the former permit better settling of the lees or argols. To guard against possible fermentation through defects in the mouth of the vessels, it is a good plan to pour a small quantity of molten paraffin over the cork after it is in place, and allow the paraffin to solidify before transferring the containers to the vaults. The sealed vessels containing the sterile juice are placed in the vaults and allowed to remain undisturbed for several months, so that the juice may clarify and the excess of acid tartrates be thrown out. To obtain the best precipitation, the temperatures in the vaults should be kept as low as possible, i. e., as close to 32° F. as can be maintained without danger of freezing.

SIPHONING THE JUICE.

As cream of tartar is least soluble at low temperatures, the juice should be siphoned only during the winter months. At the close of the precipitation period, comprising from 4 to 5 months, the corks are drawn, and the clear juice siphoned into jugs. The siphon consists of an aluminum tube bent U shape, over one end of which a piece of rubber tubing of the desired length is drawn. The siphon is placed in the vessel just out of reach of the sediment, and gentle suction applied at the rubber end until the juice starts to flow. The sediment remaining in the precipitation vessels is poured on several thicknesses of burlap stretched on a frame, and the juice allowed to drain. This juice, which is thick and muddy on account of small crystals of cream of tartar and other material, is again treated in the sterilizer, and poured into carboys in the same manner as the juice proper, and again stored for precipitation and subsequent siphoning. This juice, called "seconds," is mixed with the first siphoned juice. The residue on the burlap, called "argols," consists chiefly of acid salts of tartaric acid.

Experiments conducted by manufacturers for the purpose of clarifying the juice during the precipitation period with the white of egg and gelatin have met with little or no success. This failure is to be expected, in consideration of the fact that heated grape juice contains pectins and gummy substances, and that the juice itself has a very marked viscosity. Of course, it is always possible to remove the suspended matter by filtration, but this is a very tedious operation, and it is doubtful whether it is worth the trouble.

During the storage period the juice passes through a number of important changes. The hot juice when placed in the carboy has a beautiful bright red color. As it cools it becomes turbid, and the color takes on a brownish tint. The hot juice is full-bodied and has a harsh acid taste. The stored juice has a reddish-brown color, is more or less muddy, and has a pleasant taste and aroma. The loss in acidity during storing is due chiefly to the crystallizing of acid salts of tartaric acid. These salts are soluble to the extent of about 0.6 gram per 100 cubic centimeters in the stored juice; consequently any amount of them contained in a juice in excess of 0.6 gram will be precipitated.

To determine the amount of material precipitated during storing, the sediment contained in a carboy, which had been in storage about one year and shipped from Chautauqua County, N. Y., to Chicago, Ill., by express, was collected, dried, and weighed. It was found to amount to 0.42 gram per 100 cubic centimeters of juice.

With the precipitate a part of the tannin and coloring matter is thrown down; consequently the resultant juice has a milder, more pleasant, and decidedly less acid taste.

Table 7 gives a comparison of the analyses of 22 juices, comprising 11 sets, half of which were analyzed at the time of storing and half after 4 months' storage.

The juices marked "Before" are the fresh juices taken while hot from the sterilizing kettles, and those marked "After" are the same juices after having been stored about 4 months. The differences in composition are striking. In Table 8 the material given in Table 7 is condensed to show the maxima, minima, and averages of the two sets of juices, and the average losses of the various ingredients during the storing period.

Table 8 shows a number of interesting facts. There is a substantial decrease in solids during storing, about one-half of which is accounted for by the precipitation of cream of tartar and earth alkali tartrates. The other half is probably due to the precipitation of pectin bodies and gums. There is no material difference between the sugar contents of fresh and stored juice. With the precipitation of cream of tartar other ingredients, such as tannin and coloring matter, earth alkali tartrates, and gums and pectins, come down. The precipitation of cream of tartar is also attended by a definite decrease in nonsugar solids, total acids, total tartaric acid, and the alkalinity of the ash. While the amounts of the constituents vary in the case of the fresh juices, they seem to have approached an equilibrium in the stored juices. This is especially true of the cream of tartar.

TABLE 7.—*Chemical composition of Concord grape juice at time of storing and after 4 months' storage.*

Analysis before or after storage.	Solids, per 100 cc.	Alcohol, by volume.	Sugars as invert, before inversion, per 100 cc.	Sugars as invert, after inversion, per 100 cc.	Nonsugar solids, per 100 cc.	Total acid as tartaric, per 100 cc.	Total tartaric acid, free and combined, per 100 cc.	Free tartaric acid, per 100 cc.	Cream of tartar, per 100 cc.	Ash, per 100 cc.	Alkalinity soluble ash, N/10 acid, per 100 cc.	Alkalinity insoluble ash, N/10 acid, per 100 cc.	Tannin and coloring matter, per 100 cc.
	Grams.	*P. ct.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Cc.*	*Cc.*	*Gms.*
Before	17.01	1.03	13.25	13.38	3.76	1.26	0.99	0.30	0.72	0.34	38.4	7.6	0.26
After	16.41	1.07	13.34	13.47	3.07	1.10	.72	.28	.47	.22	24.8	4.4	.19
Before	16.99	.64	13.55	13.60	3.44	1.11	.88	.26	.64	.34	33.8	7.6	.17
After	16.41	.70	13.58	13.45	2.83	1.01	.69	.24	.49	.24	25.8	4.4	.13
Before	17.01	......	13.95	13.99	3.06	1.08	1.03	.24	.85	.44	45.2	7.2	.28
After	16.62	.07	13.80	13.89	2.82	.95	.78	.23	.60	.30	32.0	4.6	.21
Before	17.59	......	14.45	14.60	3.14	1.08	.97	.24	.77	.39	40.8	7.6	.20
After	17.17	.09	14.50	14.41	2.67	1.02	.84	.27	.63	.32	33.6	4.4	.16
Before	18.50	......	15.11	15.15	3.39	1.07	1.02	.31	.74	.37	39.6	8.0	.19
After	17.69	.06	14.99	14.95	2.70	.92	.69	.19	.54	.27	28.6	4.6	.17
Before	19.76	......	16.39	16.55	3.37	1.04	1.00	.24	.80	.39	42.8	7.6	.20
After	19.18	.10	16.15	16.30	3.03	.91	.75	.27	.53	.29	28.0	3.8	.18
Before	17.35	......	13.97	14.05	3.38	.98	.90	.13	.81	.39	43.2	8.0	.15
After	16.47	.13	13.87	13.82	2.60	.83	.65	.13	.57	.31	30.4	4.4	.13
Before	18.48	.14	15.07	15.11	3.41	1.25	.85	.15	.73	.37	39.0	8.0	.26
After	17.95	.23	15.02	15.13	2.93	1.07	.66	.22	.50	.24	26.6	3.0	.22
Before	17.84	.58	14.32	14.49	3.52	1.27	.97	.17	.86	.40	45.6	8.0	.24
After	17.33	.69	14.32	14.30	3.01	1.07	.58	.14	.49	.24	26.0	3.4	.17
Before	18.08	......	14.70	14.74	3.38	1.22	.89	.19	.76	.37	40.4	6.4	.22
After	17.85	.23	14.88	14.84	2.97	1.08	.67	.22	.50	.27	26.4	3.4	.17
Before	18.50	......	15.10	15.21	3.40	1.22	.90	.15	.80	.38	42.8	7.2	.27
After	18.22	.10	15.26	15.21	2.96	1.09	.70	.21	.55	.27	29.0	3.6	.20

TABLE 8.—*Maxima, minima, and averages of data given in Table 7: Changes in chemical composition of Concord grape juice resulting from 4 months' storage.*

	Solids, per 100 cc.	Sugar as invert, before inversion, per 100 cc.	Sugar as invert, after inversion, per 100 cc.	Nonsugar solids, per 100 cc.	Total acid as tartaric, per 100 cc.	Total tartaric acid, free and combined, per 100 cc.	Free tartaric acid, per 100 cc.	Cream of tartar, per 100 cc.	Ash, per 100 cc.	Alkalinity soluble ash, N/10 acid, per 100 cc.	Alkalinity insoluble ash, N/10 acid, per 100 cc.	Tannin and coloring matter, per 100 cc.
Before:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Cc.*	*Cc.*	*Grams.*
Maximum	19.76	16.39	16.55	3.76	1.27	1.03	0.31	0.86	0.44	45.6	8.0	0.28
Minimum	16.99	13.25	13.38	3.06	.98	.85	.13	.64	.34	33.8	6.4	.15
Average	17.92	14.54	14.62	3.38	1.14	.94	.21	.77	.39	41.1	7.5	.22
After:												
Maximum	19.18	16.15	16.30	3.07	1.10	.84	.28	.63	.32	33.6	4.6	.22
Minimum	16.41	13.34	13.45	2.60	.83	.58	.13	.47	.22	24.8	3.0	.13
Average	17.39	14.52	14.52	2.87	1.01	.70	.22	.53	.27	28.3	4.0	.18
Average loss	.53	.02	.10	.51	.13	.24	—.01	.24	.12	13.0	3.5	.04

A hot grape juice represents a supersaturated solution of cream of tartar. As the juice in the carboy cools, the cream of tartar crystallizes until the solution is reduced to the point of saturation. This change from the supersaturated to the saturated condition is very gradual, so that the time allowed for the precipitation has a decided effect upon the amount of cream of tartar retained in solution. This is shown in Table 9, wherein it will be noticed that the cream of tartar content has diminished during the additional one year of storage. Shaking a grape juice hastens the precipitation of cream of tartar, and brings about an equilibrium much more rapidly than simply allowing the juice to stand undisturbed. It seems therefore that the process of manufacture could be shortened, if after a few days' storing the juice were given a thorough shaking, and then allowed to stand for the rest of the storage period. It also seems reasonable to believe that this extra manipulation would give a much brighter finished product.

TABLE 9.—*Chemical composition of Concord grape juice after 4 months' storage and after 16 months' storage.*

Storage period.	Solids, per 100 cc.	Alcohol by volume.	Sugar as invert, before inversion, per 100 cc.	Sugar as invert, after inversion, per 100 cc.	Nonsugar solids, per 100 cc.	Total acid as tartaric, per 100 cc.	Total tartaric acid, free and combined, per 100 cc.	Free tartaric acid, per 100 cc.	Cream of tartar, per 100 cc.	Ash, per 100 cc.	Alkalinity soluble ash, N/10 acid, per 100 cc.	Alkalinity insoluble ash, N/10 acid, per 100 cc.	Tannin and coloring matter, per 100 cc.
Months.	*Gms.*	*Per ct.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Cc.*	*Cc.*	*Gms*
4	17.43	0.07	14.45	14.40	2.98	0.95	0.68	0.15	0.58	0.31	31.0	4.2	0.16
16	17.48	.07	14.60	14.70	2.88	.94	.67	.20	.51	.25	27.0	4.6	.14
4	16.47	.13	13.87	13.82	2.60	.83	.65	.13	.57	.31	30.4	4.4	.13
16	16.47	.14	14.00	13.98	2.47	.83	.60	.16	.49	.26	25.8	3.8	.12
4	17.85	.05	14.42	14.36	3.43	1.10	.82	.27	.58	.35	30.8	5.8	.26
16	17.80	.07	14.54	14.64	3.26	1.06	.72	.28	.41	.26	21.6	7.6	.20
4	19.00	.07	15.70	15.77	3.30	1.11	.69	.28	.43	.23	23.0	4.4	.33
16	19.10	.07	15.90	15.95	3.20	1.14	.65	.27	.35	.22	18.6	7.0	.16
4	18.53	.06	15.06	15.06	3.47	1.13	.83	.33	.54	.28	28.8	4.6	.33
16	18.48	.07	15.20	15.30	3.28	1.10	.70	.31	.38	.22	20.0	6.0	.16
4	18.79	.13	15.48	15.68	3.31	1.13	.79	.29	.55	.30	29.0	4.4	.22
16	18.80	.07	15.60	15.58	3.20	1.14	.66	.28	.36	.23	19.4	6.2	.17
4	17.85	.07	14.30	14.43	3.55	1.19	.88	.37	.56	.34	30.0	4.2	.32
16	17.80	.07	14.55	14.49	3.25	1.20	.80	.41	.38	.24	20.0	6.0	.17
4	18.95	.20	15.47	15.41	3.48	1.09	.75	.22	.56	.31	29.6	6.0	.32
16	18.87	.13	15.64	15.64	3.23	1.10	.68	.26	.41	.25	21.8	6.0	.17
Maximum:													
4	19.00	.20	15.70	15.77	3.55	1.19	.88	.37	.58	.35	31.0	6.0	.33
16	19.10	.14	15.90	15.95	3.28	1.20	.80	.41	.51	.26	27.0	7.6	.20
Minimum:													
4	16.47	.06	13.87	13.82	2.60	.83	.65	.13	.43	.23	23.0	4.2	.13
16	16.47	.07	14.00	13.98	2.47	.83	.60	.16	.35	.22	18.6	3.8	.12
Average:													
4	18.11	.10	14.84	14.87	3.27	1.07	.76	.26	.55	.30	29.1	4.8	.26
16	18.10	.09	15.00	15.04	3.10	1.06	.69	.27	.41	.24	21.8	5.9	.16
Average loss	.01	.01	......	......	.17	.01	.07	......	.14	.06	7.3	......	.10

Small amounts of alcohol have a decided effect on the general clarification of a juice, lowering the viscosity and insuring a better precipitation of cream of tartar. Table 11, group 2, shows that stored juices containing the least alcohol have a higher cream of tartar content than those with greater amounts of alcohol. It seems improbable, however, that the small amounts of alcohol contained in the juices in question could be solely responsible for this difference in cream of tartar content.

Table 9 gives a comparison of the analyses of 16 juices, comprising 8 sets, half of which were analyzed after 4 months' storage and half after 16 months' storage. Each two lines of data in the table represent a sample of the regular juice bottled after 4 months' storing, and the same juice after an additional storing of 1 year. Although the difference is very marked in the case of the ash and tannin content, it is not very pronounced in the other contents. The data show that 4 months of storing is not a sufficient time for complete precipitation.

BOTTLING AND PASTEURIZING THE TRADE JUICE.

The next step is that of pasteurizing the juice in the bottle. This operation should be very carefully superintended because any defect leads to fermentation and consequent loss. The pasteurizing temperature varies in the different factories, ranging from 160° to 175° F. As a rule, when the bottles are filled cold, the juice reaches the pasteurizing temperature in about 10 minutes, is allowed to remain at pasteurizing temperature for about 30 minutes, and cooled off in 10 minutes. When filled hot, from 20 to 25 minutes at pasteurizing temperature are sufficient. The length of the heating period varies with the size of the package to be sterilized, 55 minutes sufficing with pint and quart containers. Packages holding more than a quart should be filled hot.

The siphoned juice is strained through several thicknesses of burlap, and collected in a vat connected with the filling machines. The practice of filtering the juice through paper pulp, employed in some factories, did not seem to improve the appearance of the juice very much. The packages are filled with the juice by means of beer fillers, and immediately sealed, either with corks or metallic seals. When corks are used it is necessary to heat the juice before bottling to avoid blowing. A temperature of about 160° F. is ordinarily used for this. When metallic seals are used for smaller packages it is not necessary to heat the juice before filling them. Packages holding more than a quart should, however, be filled hot to avoid breakage.

MANUFACTURE OF GRAPE JUICE IN THE LAKE ERIE DISTRICT.

The method of manufacture of the juices from the Lake Erie district differed greatly from the methods which have been described. The grapes were not stemmed before heating, and the juice was stored for precipitation in barrels instead of in 5-gallon containers. For the most part, grapes grown on the Bass Islands, in Lake Erie, to the north of Sandusky, Ohio, were used in the preparation of the juices. The fruit, which was of good quality, was immediately crushed and heated without being stemmed. The pulp was heated in aluminum kettles to about 145° F., and pressed on hydraulic presses in the customary manner. The juice was strained through several thicknesses of burlap, heated in glass-lined kettles to about 175° F., after which it was run into 50-gallon barrels, previously sterilized by steam. The barrels were filled to the tops with the hot juice, and immediately carefully bunged. After having been stored for precipitation, the juice was run into the trade packages and sterilized in the customary manner.

OCCURRENCE OF SMALL AMOUNTS OF ALCOHOL.

Under usual factory conditions it is impossible to produce juices which are wholly free from alcohol. Grapes are carriers of yeast cells, and the juice itself is an ideal medium for yeasts. Moreover, the temperatures attained during the latter part of the pressing process are very favorable to conditions yielding alcoholic fermentation. Then again, as the pressing season advances, the press beds, racks, press cloths, and floors of the factory become thoroughly impregnated with vigorous yeast cells. The danger from alcoholic fermentation is still further increased by the fact that the yeast cells brought in on the grapes to the air of the factory assist in starting fermentation wherever conditions of temperature are favorable.

Special care was taken to discover the causes for the occurrence of small amounts of alcohol occasionally found in commercial grape juices. One possible cause is undoubtedly the fermentation in the fruit itself. As has been shown, however, grapes of good quality contain such small amounts of alcohol that this source may be disregarded. The principal cause must, therefore, be sought in the manufacturing process. Tables 7 and 9 show that the alcohol content does not increase in the precipitation vessel during storage. Improper methods of pasteurization might, of course, cause fermentation in the trade package, but alcoholic fermentation, once started, would proceed very rapidly until it finally destroyed the package.

A very definite development of alcohol was found to occur during the pressing period in one establishment. Alcohol was distinctly discernible by odor, and toward the end of the pressing frothing set in. Samples of the material were taken at the various pressing stages and analyzed for alcohol. Table 10 shows the results thus obtained.

TABLE 10.—*Percentage of alcohol by volume in a particular Concord grape juice at various stages of pressing.*

Stage.	Experiment 1.	Experiment 2.
Heated pulp	0.08	0.09
First of free run	.80	.66
Last of free run	1.36	1.56
Last of low pressure at 30 tons	.86	1.60
Last of high pressure at 110 tons	2.06	2.60
Composite of juice	.60	.75

The total time consumed by the pressing period, including the settling period, was 2 hours and 50 minutes. The figures show a normal alcoholic content for the pulp, and an increased alcoholic content as the cheese cools.

From the tables of composition it is seen that of the 104 samples of juices recorded 44 per cent show 0.10 per cent or less of alcohol by volume; 77 per cent show 0.20 per cent or less of alcohol by volume; 83 per cent show 0.30 per cent or less of alcohol by volume; 90 per cent show 0.40 per cent or less of alcohol by volume. The remaining 10 per cent of the samples show an alcoholic content ranging from 0.40 to 1.07 per cent by volume.

It is interesting to note that all of the samples showing more than 0.40 per cent of alcohol are members of group 2, season 1912. In the manufacture of these juices the settling period was materially longer than that usually allowed. The juices of the seasons 1913 and 1914 of the same group, in the preparation of which a shorter settling period was used, show a decidedly lower content of alcohol. It is evident then that the danger period of alcoholic development is confined to the time allowed for the pressing of the juice, and that this danger may be reduced to a minimum by reducing the time for this part of the process.

INTRODUCTION OF WATER DURING MANUFACTURE.

A small amount of water is introduced into the juice during the process of manufacture. The stages at which the water may enter are (1) washing the grapes, (2) washing the press cloths, (3) washing receptacles, such as kettles, vats, carboys, and vessels. Although a great many experiments were conducted to determine the amounts of water in the finished product due to these additions, no definite results were obtained.

It is evident that the washing of grapes introduces water into the juice. The amount depends upon the time the grapes remain in the water, and upon the manner in which the washed grapes are drained. Experiments to determine the amount of water retained by the grapes showed that 2.5 per cent is held, or for 1 ton of grapes about

6 gallons of water would be introduced. Although only approximate, it is believed that this figure gives a fair representation of the true condition. The content in solids was invariably slightly lower in the case of juice made from grapes which had been washed than in the case of juice from grapes which had not been washed. It was found that about 6 pounds of water was retained in the washed and centrifuged cloths of standard size for 48 by 48 inch racks.

Experiments were conducted to determine the amount of water introduced by washing the grapes and washing the press cloths. Runs wherein the grapes were washed, and washed and centrifuged cloths were used, and runs wherein the grapes were not washed and new dry cloths were used, were made. Although a slightly heavier juice was obtained under the latter conditions, the difference was not great enough to allow of definite conclusions.

Judging from all the experiments and from the chemical composition of the juices, made with and without the use of water, it is believed that about 3 grams of water per 100 cubic centimeters are introduced into the juice during the washing and pressing of the grapes. The amount of water added during the washing of the receptacles is regulated by factory practice.

CHEMICAL COMPOSITION OF GRAPE JUICE.

The analyses of the 104 commercial juices taken during the investigations are given in Table 11. This material is divided into six groups, each group representing the juices from one factory. Group 1 comprises the samples from the Hudson River district. The first 15 samples represent juices made from washed grapes, the remainder those from unwashed grapes. The settling period was about 15 minutes. Groups 2, 3, 4, and 5 comprise the samples from the Chautauqua belt. The grapes of group 2 were washed. During the seasons 1914 and 1915 the time allowed for the settling of the cheese before pressing was shortened to about 25 minutes. Groups 3, 4, and 5 are juices made from unwashed grapes. The settling period was about 15 minutes. Group 6 comprises the juices made from grapes of the Lake Erie district. For the description of the manufacturing process see page 4. The 1912 samples of group 2 are not included in Table 11, because the alcohol content of this set is abnormally high for a properly prepared grape juice.

TABLE 11.—*Chemical composition of Concord grape juices.*

Group and season.	Solids, per 100 cc.	Alcohol by volume.	Sugars as invert, before inversion, per 100 cc.	Sugars as invert, after inversion, per 100 cc.	Non-sugar solids, per 100 cc.	Polarizations, normal weight, 200 mm. tube.			Total acidity calculated as tartaric, per 100 cc.	Total tartaric acid, free and combined, per 100 cc.	Free tartaric acid, per 100 cc.	Cream of tartar, per 100 cc.	Ash, per 100 cc.	Alkalinity of water-soluble ash, N/10 acid, per 100 cc.	Alkalinity of water-insoluble ash, N/10 acid, per 100 cc.	Tannin and coloring matter, per 100 cc.
						Direct at 20° C.	Invert at 20° C.	Invert at 87° C.								
Group 1.	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	° *V.*	° *V.*	° *V.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Cc.*	*Cc.*	*Grams.*
1912	14.20	0.07	11.52	11.41	2.68	4.3	4.4	1.0	0.87	0.59	0.15	0.47	0.25	25.2	4.4	0.19
	15.55	.09	13.00	13.18	2.55	4.9	4.9	1.1	.94	.72	.19	.59	.28	31.2	4.2	.07
	15.63	.04	13.04	13.08	2.59	4.9	4.9	1.0	.95	.69	.20	.55	.27	29.4	3.6	.11
	14.72	.07	11.66	11.66	3.06	4.5	4.5	1.0	1.09	.82	.24	.65	.30	34.8	4.2	.18
	15.37	.13	12.67	12.58	2.70	4.8	4.8	1.4	1.01	.63	.15	.53	.28	28.0	3.8	.17
	15.81	.08	13.20	13.19	2.61	5.2	5.1	1.4	.88	.68	.19	.53	.26	28.2	4.6	.18
	14.98	.08	12.21	12.26	2.77	4.6	4.6	1.2	1.00	.64	.20	.48	.25	25.6	4.0	.15
	15.03	.10	12.38	12.24	2.65	4.8	4.7	0.8	.96	.65	.20	.47	.26	25.0	5.0	.16
	15.35	.07	12.51	12.36	2.84	4.8	4.9	1.0	1.08	.73	.19	.60	.30	32.0	3.8	.16
	15.71	.07	12.54	12.65	3.17	5.0	5.0	1.0	1.01	.76	.21	.61	.30	32.6	4.4	.18
	16.62	.07	13.80	13.89	2.82	5.6	5.6	1.0	.95	.78	.23	.60	.30	32.0	4.6	.21
	16.02	.07	13.19	13.30	2.83	5.0	5.1	1.0	.92	.73	.22	.57	.30	30.2	4.2	.22
	16.75	.06	13.52	13.52	3.23	5.3	5.4	1.2	1.03	.82	.19	.71	.37	37.7	4.2	.22
	17.17	.09	14.50	14.41	2.67	5.9	5.8	0.9	1.02	.84	.27	.63	.32	33.6	4.4	.16
	16.07	.04	12.87	12.80	3.20	5.0	5.1	1.0	1.07	.86	.26	.67	.34	35.6	4.6	.21
	16.36	.06	13.64	13.74	2.72	5.6	5.5	1.2	.81	.60	.12	.52	.28	27.8	4.4	.17
	16.28	.13	13.41	13.46	2.87	5.8	5.7	1.6	.95	.66	.21	.52	.27	27.4	3.2	.20
	16.68	.07	13.98	13.86	2.70	5.8	5.8	1.0	.91	.62	.16	.50	.26	26.4	4.0	.18
	16.70	.06	13.99	13.92	2.71	5.9	5.8	1.4	.89	.67	.19	.51	.25	27.2	4.8	.18
	17.43	.10	14.62	14.60	2.81	6.2	6.2	1.6	.91	.79	.27	.56	30	30.0	4.6	.19
	17.69	.06	14.99	14.95	2.70	6.1	6.2	1.2	.92	.69	.19	.54	.27	28.6	4.6	.17
	19.18	.10	16.15	16.30	3.03	6.7	6.5	1.0	.91	.75	.27	.53	.29	28.0	3.8	.18
	16.69	.13	13.76	13.96	2.93	6.1	6.0	1.4	.99	.79	.27	.56	.29	29.8	4.8	.18
	17.43	.07	14.45	14.40	2.98	6.3	6.3	1.2	.95	.68	.15	.58	.31	31.0	4.2	.16
	16.47	.13	13.87	13.82	2.60	6.0	6.0	1.0	.83	.65	.13	.57	.31	30.4	4.4	.13
Group 2:																
1912	17.80	.04	14.62	14.68	3.18	5.7	5.8	1.0	.97	.76	.17	.63	.31	33.6	6.0	.13
	18.22	.10	15.26	15.21	2.96	5.9	5.9	1.0	1.09	.70	.21	.55	.27	29.0	3.6	.20
	17.85	.23	14.88	14.84	2.97	5.9	5.8	1.8	1.08	.67	.22	.50	.27	26.4	3.4	.17
	17.95	.23	15.02	15.13	2.93	6.0	5.9	1.2	1.07	.66	.22	.50	.24	26.6	3.0	.22
	17.90	.36	15.04	14.88	2.86	6.5	6.5	1.8	1.04	.68	.24	.48	.26	25.6	3.8	.19
	17.18	.37	14.31	14.44	2.87	5.8	5.8	1.2	1.10	.71	.26	.47	.25	25.2	5.0	.20
	17.64	.40	14.80	14.70	2.84	6.0	5.9	1.6	1.04	.60	.14	.49	.24	26.0	4.4	.15
	16.28	.80	13.14	13.06	3.14	5.6	5.5	1.0	1.10	.65	.23	.44	.22	23.2	4.6	.19
	17.33	.69	14.32	14.30	3.01	6.0	6.1	1.4	1.07	.58	.14	.49	.24	26.0	3.4	.17

TABLE 11.—*Chemical composition of Concord grape juices*—Continued.

Group and season.	Solids, per 100 cc.	Alcohol by volume.	Sugars as invert, before inversion, per 100 cc.	Sugars as invert, after inversion, per 100 cc.	Non-sugar solids, per 100 cc.	Polarizations, normal weight, 200 mm. tube.			Total acidity calculated as tartaric, per 100 cc.	Total tartaric acid, free and combined, per 100 cc.	Free tartaric acid, per 100 cc.	Cream of tartar, per 100 cc.	Ash, per 100 cc.	Alkalinity of water-soluble ash, N/10 acid, per 100 cc.	Alkalinity of water-insoluble ash, N/10 acid, per 100 cc.	Tannin and coloring matter, per 100 cc.
						Direct at 20° C.	Invert at 20° C.	Invert at 87° C.								
	Grams.	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	° *V.*	° *V.*	° *V.*	*Grams.*	*Grams.*	*Grams.*	*Grams*	*Grams.*	*Cc.*	*Cc.*	*Grams.*
Group 2—Continued.																
1912	16.41	1.07	13.34	13.47	3.07	5.9	5.8	1.0	1.10	.72	.28	.47	.22	24.8	4.4	.19
	16.39	.77	13.54	13.54	2.85	5.9	5.8	1.2	1.02	.69	.23	.48	.25	25.4	5.0	.17
	16.05	.98	13.26	13.18	2.79	5.8	5.8	1.0	1.04	.66	.24	.45	.23	24.0	4.2	.16
	17.62	.70	14.76	14.67	2.86	6.2	6.2	1.2	1.07	.75	.32	.45	.23	23.8	4.8	.17
	16.73	.57	13.88	13.75	2.85	6.0	5.9	1.0	1.08	.68	.26	.44	.23	23.2	5.0	.18
	16.41	.70	13.58	13.45	2.83	5.8	5.9	1.2	1.01	.69	.24	.49	.24	25.8	4.4	.13
	17.38	.82	14.36	14.32	3.02	6.3	6.4	1.8	1.07	.73	.29	.49	.25	25.8	3.4	.19
	17.35	.20	14.61	14.58	2.74	6.1	6.2	1.4	.98	.65	.10	.58	.30	31.0	5.5	.18
	17.95	.53	14.81	14.73	3.14	6.3	6.2	1.4	1.11	.84	.29	.62	.31	33.0	3.8	.21
1913	18.76	.33	15.89	15.95	2.87	7.0	7.0	1.4	.92	.62	.19	.45	.24	24.0	4.4	.16
	18.27	.23	15.53	15.55	2.74	6.6	6.5	1.0	.94	.64	.19	.49	.24	26.0	4.2	.16
	17.80	.33	14.80	14.88	3.00	6.3	6.3	1.7	.99	.64	.22	.45	.23	23.8	4.2	.16
	19.08	.14	15.89	15.82	3.19	6.7	6.6	1.7	1.04	.74	.18	.63	.29	33.4	4.0	.17
	18.95	.10	15.88	15.96	3.07	6.3	6.4	1.2	1.05	.74	.16	.61	.30	32.2	6.8	.18
	18.90	.23	16.09	16.18	2.81	6.4	6.4	1.2	.94	.62	.13	.50	.26	26.8	5.6	.15
1914	19.05	.12	16.57	16.53	2.48	6.2	6.2	1.3	.99	.81	.30	.54	.26	28.6	5.6	.17
	19.71	.11	17.04	16.98	2.67	6.3	6.3	1.4	.98	1.01	.36	.70	.32	37.2	5.8	.15
	18.63	.16	16.18	16.14	2.45	6.1	6.2	1.2	.98	.75	.22	.55	.27	29.4	6.2	.14
	19.29	.02	16.69	16.72	2.60	6.2	6.3	1.3	.99	.88	.19	.79	.34	42.0	4.0	.16
Group 3:																
1912	18.66	.13	15.65	15.50	3.01	5.9	6.0	1.6	1.16	.73	.24	.52	.32	27.6	5.2	.24
	18.90	.13	15.70	15.79	3.20	6.2	6.2	1.4	1.01	.67	.20	.47	.28	25.2	6.4	.30
	18.79	.13	15.63	15.64	3.16	6.0	6.0	1.4	1.05	.66	.20	.46	.28	24.4	6.2	.31
	19.81	.13	16.51	16.64	3.30	6.8	6.7	1.4	1.05	.62	.22	.41	.23	22.0	4.8	.30
	19.44	.26	16.05	15.99	3.39	6.7	6.6	1.5	1.09	.70	.27	.43	.24	23.0	5.6	.30
	18.95	.20	15.63	15.73	3.32	6.2	6.2	1.4	1.13	.68	.26	.43	.25	23.0	4.8	.28
1913	19.29	.12	15.94	16.00	3.35	6.2	6.3	1.4	1.00	.68	.25	.45	.25	24.0	4.4	.32
	19.84	.13	16.59	16.56	3.25	6.5	6.5	1.4	1.09	.85	.36	.53	.28	28.0	5.0	.26
	20.52	.11	16.96	16.91	3.56	6.9	7.0	1.5	1.01	.72	.21	.55	.30	29.0	5.3	.34
	19.71	.20	16.39	16.48	3.32	6.5	6.4	1.0	1.05	.79	.31	.49	.25	26.0	6.0	.35
	20.26	.16	17.14	17.23	3.12	6.7	6.7	1.4	1.07	.73	.20	.51	.28	27.0	8.2	.22
1914	19.34	.03	16.79	16.83	2.55	6.2	6.2	1.5	1.03	.96	.26	.79	.37	42.0	4.7	.22
	19.34	.08	16.59	16.53	2.75	6.3	6.2	1.4	1.01	.90	.29	.68	.33	36.4	4.3	.26

Group 4:																
1912	17.93	.11	14.68	14.66	3.25	5.7	5.8	1.4	1.16	.74	.25	.51	.29	27.0	5.6	.30
	18.19	.04	14.91	14.80	3.28	5.5	5.4	1.3	1.23	.83	.23	.68	.34	36.0	4.0	.28
	18.53	.06	15.06	15.06	3.47	5.6	5.6	1.1	1.13	.83	.33	.54	.28	28.8	4.6	.33
	17.85	.05	14.42	14.36	3.43	5.4	5.5	1.1	1.16	.92	.28	.69	.35	36.8	5.8	.26
	19.00	.07	15.70	15.77	3.30	6.0	5.9	1.0	1.11	.69	.28	.43	.23	23.0	4.4	.33
	18.66	.07	15.67	15.68	2.99	6.0	6.2	1.2	1.04	.77	.24	.58	.29	30.6	5.0	.24
	19.60	.07	16.12	16.20	3.48	6.3	6.5	1.3	1.13	.79	.33	.49	.27	26.0	5.0	.29
	20.39	.13	17.09	17.05	3.30	6.8	6.8	1.2	1.08	.65	.23	.47	.26	25.2	3.1	.37
1913	20.78	.13	17.35	17.48	3.43	6.8	6.8	1.4	1.02	.62	.17	.47	.24	25.0	5.2	.36
	20.36	.10	16.77	16.80	3.59	6.6	6.7	1.4	.95	.56	.21	.38	.22	20.0	3.4	.35
	19.37	.10	16.15	16.18	3.22	6.5	6.4	1.6	1.04	.72	.26	.49	.27	26.0	4.4	.26
	20.07	.10	16.80	16.97	3.27	6.6	6.4	1.4	1.11	.56	.18	.36	.22	19.0	6.6	.32
	20.23	.07	17.05	17.16	3.18	6.7	6.6	1.4	1.01	.62	.19	.41	.24	22.0	6.8	.32
1914	18.92	.06	16.24	16.31	2.68	5.9	6.0	1.6	.99	.73	.24	.48	.26	25.6	7.0	.28
	19.36	.32	16.88	16.83	2.48	5.8	5.9	1.3	.99	.77	.33	.47	.23	25.0	4.6	.30
	19.39	.14	16.62	16.62	2.77	5.8	5.8	1.4	1.04	.80	.32	.50	.26	26.8	5.2	.33
Group 5:																
1912	17.88	.13	14.69	14.72	3.19	5.5	5.4	1.3	1.19	.86	.28	.64	.32	34.2	4.6	.23
	18.06	.07	15.00	15.02	3.06	5.9	5.9	1.4	1.28	.92	.27	.73	.36	39.0	4.4	.30
	18.22	.13	14.75	14.77	3.47	5.5	5.6	1.7	1.20	.81	.23	.64	.31	34.0	4.6	.34
	18.06	.07	14.45	14.56	3.61	5.5	5.6	1.6	1.13	.80	.23	.60	.32	32.0	6.2	.34
	17.85	.07	14.30	14.43	3.55	5.6	5.7	1.4	1.19	.90	.30	.67	.34	35.6	4.2	.32
	17.88	.13	14.30	14.40	3.58	5.9	5.8	1.4	1.13	.73	.23	.55	.32	29.0	4.4	.27
	18.95	.20	15.47	15.41	3.48	6.4	6.3	1.2	1.09	.75	.22	.56	.31	29.6	6.0	.32
	18.79	.13	15.48	15.68	3.31	6.3	6.4	1.6	1.13	.79	.29	.55	.30	29.0	4.4	.22
1913	18.97	.13	15.68	15.75	3.29	6.0	6.0	1.8	1.01	.65	.25	.41	.23	22.0	5.0	.34
	19.55	.16	16.36	16.48	3.19	6.7	6.8	1.2	.97	.59	.21	.38	.22	20.0	5.0	.31
	20.62	.20	17.28	17.37	3.34	7.0	7.0	1.6	.91	.63	.19	.46	.25	24.4	5.0	.30
	19.31	.13	15.71	15.81	3.60	6.3	6.4	1.6	1.08	.79	.31	.52	.28	27.6	4.2	.31
	19.94	.13	16.41	16.59	3.53	6.6	6.6	1.8	.95	.57	.20	.40	.22	21.0	3.8	.32
1914	19.16	.05	16.27	16.29	2.89	6.6	6.7	1.5	.98	.80	.22	.60	.31	32.0	6.4	.28
	20.02	.09	17.38	17.33	2.64	6.8	6.8	1.4	.98	.88	.21	.71	.34	37.8	6.8	.30
Group 6:																
1914	19.81	.09	17.06	16.93	2.75	6.2	6.3	1.5	.93	.82	.22	.62	.34	33.0	7.4	.18
	19.92	.05	16.88	16.79	3.04	6.3	6.3	1.4	1.01	.82	.27	.54	.34	28.8	8.0	.18
	20.39	.04	17.53	17.53	2.86	6.6	6.5	1.6	.96	.82	.28	.52	.32	27.4	8.8	.24
	19.05	.20	16.51	16.46	2.54	6.1	6.2	1.4	.91	.78	.26	.52	.31	27.8	6.8	.17
	19.65	.22	17.11	17.06	2.54	6.3	6.3	1.4	.87	.77	.26	.49	.29	26.0	7.8	.22
	19.23	.29	16.31	16.36	2.92	6.1	6.2	1.4	.91	.75	.25	.50	.30	26.8	6.6	.20
	19.60	.37	16.64	16.74	2.96	6.3	6.4	1.4	.90	.73	.29	.45	.30	23.8	5.6	.19
SUMMARY:																
Group 1—																
Max	19.18	.13	16.15	16.30	3.23	6.7	6.5	1.6	1.09	.86	.27	.71	.37	37.7	5.0	.22
Min	14.20	.04	11.52	11.41	2.55	4.3	4.4	0.8	.81	.59	.12	.47	.25	25.0	3.2	.07
Av.	16.24	.08	13.42	13.41	2.82	5.4	5.4	1.1	.95	.71	.20	.56	.29	29.9	4.3	.17
Group 2—																
Max	19.71	.33	17.04	16.98	3.19	7.0	7.0	1.7	1.05	1.01	.36	.79	.34	42.0	6.8	.18
Min	17.80	.02	14.80	14.88	2.45	6.1	6.2	1.0	.92	.62	.13	.45	.23	23.8	4.0	.14
Av.	18.84	.18	16.06	16.07	2.79	6.4	6.4	1.3	.98	.75	.21	.57	.28	30.3	5.1	.16

TABLE 11.—*Chemical composition of Concord grape juices*—Continued.

Group and season.	Solids, per 100 cc.	Alcohol by volume.	Sugars as invert, before inversion, per 100 cc.	Sugars as invert, after inversion, per 100 cc.	Non-sugar solids, per 100 cc.	Polarizations, normal weight, 200 mm. tube.			Total acidity calculated as tartaric, per 100 cc.	Total tartaric acid, free and combined, per 100 cc.	Free tartaric acid, per 100 cc.	Cream of tartar, per 100 cc.	Ash, per 100 cc.	Alkalinity of water-soluble ash, N/10 acid, per 100 cc.	Alkalinity of water-insoluble ash, N/10 acid, per 100 cc.	Tannin and coloring matter, per 100 cc.
						Direct at 20° C.	Invert at 20° C.	Invert at 87° C.								
	Grams.	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*° V.*	*° V.*	*° V.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Cc.*	*Cc.*	*Grams.*
SUMMARY—continued.																
Group 3—																
Max.	20.52	.26	17.14	17.23	3.56	6.9	7.0	1.6	1.16	.96	.36	.79	.37	42.0	8.2	.35
Min.	18.66	.03	15.63	15.50	2.55	5.9	6.0	1.0	1.00	.62	.20	.41	.23	22.0	4.3	.22
Av.	19.45	.19	16.27	16.29	3.17	6.4	6.4	1.4	1.06	.75	.25	.52	.28	27.5	5.4	.29
Group 4—																
Max.	20.78	.32	17.35	17.48	3.59	6.8	6.8	1.6	1.23	.92	.33	.69	.35	36.8	7.0	.37
Min.	17.85	.04	14.42	14.36	2.48	5.4	5.4	1.0	.95	.56	.17	.36	.22	19.0	3.1	.24
Av.	19.29	.10	16.10	16.12	3.20	6.1	6.1	1.3	1.07	.72	.25	.50	.27	26.4	5.0	.31
Group 5—																
Max.	20.62	.20	17.38	17.37	3.61	7.0	7.0	1.8	1.28	.92	.31	.73	.36	39.0	6.8	.34
Min.	17.85	.05	14.30	14.40	2.64	5.5	5.4	1.2	.91	.57	.19	.38	.22	20.0	3.8	.22
Av.	18.88	.12	15.57	15.64	3.38	6.2	6.2	1.5	1.08	.77	.24	.56	.30	29.8	5.0	.30
Group 6—																
Max.	20.39	.37	17.53	17.53	3.04	6.6	6.5	1.6	1.01	.82	.29	.62	.34	33.0	8.8	.24
Min.	19.05	.04	16.31	16.36	2.54	6.1	6.2	1.4	.87	.73	.22	.45	.29	23.8	5.6	.18
Av.	19.66	.18	16.86	16.84	2.80	6.3	6.3	1.4	.93	.78	.26	.52	.31	27.7	7.3	.2
General—																
Max.	20.78	.37	17.53	17.53	3.61	7.0	7.0	1.8	1.28	1.01	.36	.79	.37	42.0	8.8	.37
Min.	14.20	.02	11.52	11.41	2.45	4.3	4.4	0.8	.81	.56	.12	.36	.22	19.0	3.1	.07
Av.	18.33	.12	15.31	15.33	3.02	6.0	6.0	1.3	1.01	.74	.23	.54	.29	28.7	5.1	.24

METHODS OF ANALYSIS.

Solids: From the specific gravity and the alcohol content. The specific gravity was obtained from the Brix reading at 17.5° C.

Alcohol: By immersion refractometer.

Nonsugar solids: From solids and sugars before inversion.

Acid: Spotted into litmus solution.

Polarizations: On solutions clarified with normal lead acetate.

Total tartaric acid: Hartmann and Eoff method (U. S. Dept. Agr., Bur. Chem. Bul. 162: 72).

Free tartaric acid and cream of tartar: Calculated from total tartaric acid and the alkalinites of the ash (U. S. Dept. Agr., Bur. Chem. Bul. 162: 75).

Tannin and coloring matter: Loewenthal's method.

ADDITIONAL DETERMINATIONS.

In the course of the investigation a number of determinations not incorporated in the tables of composition were made. These results are given in Table 12.

TABLE 12.—*Additional chemical determinations of constituents of Concord grape juice.*

Group.	P_2O_5.	Cl.	SO_3.	Volatile acid as acetic.	Nitrogen.
	Mg. per 100 cc.	*Grams per 100 cc.*	*Grams per 100 cc.*	*Grams per 100 cc.*	*Grams per 100 cc.*
1	24.2	0.0025			
	21.2	.0018			
2	16.9			0.01	
	15.5			.01	
	16.7			.01	
	17.7			.01	
3	17.5	.0018	0.0080		
	19.0	.0018	.0116		
	20.6			.01	
	20.0			.01	
4	15.6	.0014	.0082		
	18.0	.0021	.0075		
	21.1			.01	
	23.6			.01	
	22.3			.01	
	21.3	.0021			0.051
5	17.6	.0018	.0089		
	19.5			.01	
	18.6			.01	
	21.8	.0025			.054
	19.0	.0025			.054
	20.2	.0021			.043
6	39.7			.02	
	35.7			.04	
	36.9			.04	
	38.1			.03	
	39.7			.02	
	41.2			.02	
	39.4			.03	

The volatile esters were also determined on 19 samples from the six different factories, and found to range between 0.12 and 0.23 gram per 100 cubic centimeters, with an average of 0.16 gram per 100 cubic centimeres.

SUMMARY.

Generally speaking, a Concord grape juice properly prepared contains small amounts of alcohol. The juice contains more than 0.4 per cent by volume only when too much time has been allowed for the pressing period. A pure Concord grape juice has not been found to contain sucrose. The polarization of the inverted solution at 87° C. is levorotatory. The free malic acid of a grape juice, figured approximately from the acidity of the juice, free tartaric acid, and the total alkalinities of the ash,[1] amounts on an average to about 0.5 gram per 100 cubic centimeters. The Concord grape juices examined contained free tartaric acid. The cream of tartar of a Concord grape juice amounts to about 0.54 gram per 100 cubic centimeters, ranging between 0.36 and 0.79 grams.

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[1] U. S. Dept. Agr., Bur. Chem. Bul. 162: 75.

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